

GREENING SUPPLY CHAINS: IMPACT ON COST AND DESIGN

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Report Econometric Institute EI2010-39b

August, 2010

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1 Introduction

Mallidis et al. in Report Econometric Institute EI2010-39a propose a framework to assist supply chain managers in designing green supply chain networks. To be more specific, they set-up a methodology for estimating the parameters and identifying cost as also environmentally friendly supply chain configurations in a green supply chain network design problem. The applicability of the proposed methodology is examined through the development of a green supply chain network in the South Eastern Europe region.

The purpose of this report is to provide the readers with a comprehensive overview of all data and results of calculations made in Mallidis et al. (2010) on this network.

The rest of the report is organized as follows. In Section 2 the annual demand, expressed in 40ft containers, for the examined products in Bulgaria, Romania and FYROM (also known as Macedonia) is estimated, while in section 3 the gross weight capacity of the examined 40ft container is calculated. In section 4 the leasing as also outsourcing costs of deconsolidation/consolidation operations will be estimated. In Section 5, ship, truck and rail transportation costs are estimated while in section 6 their generated CO₂ and PM emissions are quantified. Finally in Section 7 the supply chain configurations along with the transportation modes utilized for each optimization criterion are analyzed.

2 Estimation of annual demand in the examined countries regions

The estimated annual demand for the examined products (kitchens, micro waves, washing machines and refrigerators) in FYROM, Bulgaria and Romania is based on (i) the estimated annual demand for the examined products in Greece (ii) the ratio of each country's regions GDP to that of Greece and (iii) the volume of a 40ft container (67 m³). Table 1 displays the annual demand for the examined products in Greece, while tables 2 and 3 the estimated monthly demand for the examined products in Bulgaria, Romania and FYROM, assuming that the company satisfies 20% of their total demand.

Table 1: Estimated annual demand (Greece)

Product	Annual (items)	Average volume (m ³)	Annual (40foot)
Refrigerators	444638	0.80	5309
Kitchens	667799	0.41	4087
Micro devices	1895000	0.13	3677
Washing machines	321395	0.41	1967
Total demand in 40ft cntrs			15040

Table 2: Estimated annual and monthly demand (Bulgaria)

Regions	Capital cities	Region /Greece GDP	Annual	Monthly (20%)
North-West	Vidin	0.0383	576	10
North-Central	Ruse	0.0370	556	9
North-East	Varna	0.0370	556	9
South-West	Sofia	0.0778	1170	19
South-Central	Plovdiv	0.0593	892	15
South-East	Burgas	0.0444	668	11

Table 3: Estimated annual and monthly demand (Romania)

Regions	Capital cities	Region /Greece GDP	Annual	Monthly (20%)
North-West	Cluj	0.0860	1293	22
Center	Brasov	0.0722	1086	18
North-East	Iasi	0.0678	1020	17
South-East	Constanta	0.0770	1158	19
South	Prahova	0.0770	1158	19
Bucharest Ilfov	Bucharest	0.1689	2540	42
West	Timisoara	0.0763	1148	19
South-West	Craiova	0.0430	647	11
Other regions	not considered	0.0741	not considered	not considered

Table 4: Estimated annual and monthly demand (FYROM)

Regions	Capital cities	Region /Greece GDP	Annual	Monthly (20%)
Skopje	Skopje	0.02815	423	7

3 Estimation of the 40ft container tonnage

Based on (i) typical weight and volume characteristics of washing machines, refrigerators, micro ovens, kitchens and (ii) the volume and weight of an empty 40ft container (approximately 4tons), we have estimated the gross tonnage of the container under study. Table 5 displays the average volume and weight characteristics of the products under study as also the average net tonnage of the examined 40ft container.

Table 5: Estimated average net tonnage

Product	Average volume (m3)	Average Weight	Kgs/m ³ /product	Net tonnage
Refrigerators	0.80	75.0	93.8	6285
Kitchens	0.41	40.0	97.6	6539
Micro devices	0.13	5.0	38.5	2580
Wash. mach.	0.41	75.0	182.9	12254
Average values	0.44	49.0	103.2	6915

4 Estimation of deconsolidation/consolidation costs

The deconsolidation/consolidation costs estimated in this section incorporate (i) the cost of leasing distribution centers (including all daily operational costs of the distribution center) of various capacities in Greece, Bulgaria, Romania and FYROM as also (ii) the cost per TEU for outsourcing deconsolidation/consolidation operations to 3PLs. The monthly leasing and outsourcing costs of deconsolidation/consolidation operations utilized in this work have been estimated based on current prices in Thes/niki (specifically for outsourcing, the cost is €120 per 40ft cntr) retrieved from V.CH. Kampakis Group. For Bulgaria and Romania these costs are approximately 20% lower while for FYROM, 40%. Table 6 displays the leasing costs of various capacity distribution centers in Greece, Bulgaria, Romania and FYROM.

Table 6: Leasing deconsolidation/consolidation costs (euro / month)

Regions \ Storage Capacity (in 40ft cnts)	60	80	100	200
Greece (Thes/niki)	10000	13000	16500	20000
Bulgaria	8000	10400	13200	16000
Romania	8000	10400	13200	16000
FYROM (Skopje)	6000	7800	9900	12000

5 Calculation of transportation costs

The transportation costs calculated in this section incorporate: (i) Euro III, IV, V and VI heavy duty and delivery truck costs per 40ft container (iii) rail and block train costs per 40ft container.

5.1 Heavy duty truck costs

For the option that involves outsourcing of transportation services, heavy duty truck freight rates per 40 foot containers are estimated based on (i) freight rates per TEU, for specific routes in the Regions of Bulgaria, Romania and FYROM and (ii) an estimated 33% freight rate increase (compared to freight rates per TEU) for 40foot containers (V.CH. Kampakis Group, “Personal Communication”). The distances of the routes have been estimated with the use of the software Euro map route planner and Google earth while cost data have been retrieved from one of the largest (3PLs) in Northern Greece namely Orphee Beinoglou INTL Forwarders SA, “Personal Communication”. Having estimated the distances in these routes along with the corresponding freight rates per 40foot container, we have then developed a regression equation. For the option that involves leasing of transportation services, truck freight rates per 40ft container are estimated to be 20% lower compared to the option that involves outsourcing (V.CH. Kampakis Group, “Personal Communication”) since (a) they are charged based on a fixed long term contract and not on a spot market basis as in outsourcing and (b) no agency fees are included since the examined company has direct communication with the truck owners. The freight rates for Euro IV, V, VI heavy duty trucks are estimated based on their purchase price differences with that of Euro III. To be more specific we consider that 75% of all Euro type truck costs incorporate the truck drivers wages and other operational expenses, such as order costs, truck maintenance costs e.t.c, while 25% the truck depreciation costs. Since the latter is proportional to the trucks purchase costs the 75% of the freight rate is the same for all trucks independently of their engines Euro norm and the rest 25% of the freight rate, changes according to the truck purchase costs that depends on the engines Euro norm. Specifically for Euro VI heavy duty trucks that are not still in use the purchase price involves an estimated value. Finally from the Entry Point to its corresponding Distribution Center, a city limit expense of 100€ is charged.

Table 7 displays the heavy duty truck freight charges per 40ft container for specific routes, while table 8 the purchase costs of the examined Euro trucks (S.Savvatis LTD, “Personal Communication”) along with their percentage freight rate differences. Finally table 9 displays the heavy duty truck freight rates in the routes examined for the options of outsourcing and leasing.

Table 7: Euro III heavy duty truck freight rates

From	To	Distance	Cost
Thes/niki	Sofia	287	798

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From	To	Distance	Cost
Thes/niki	Ruse	630	1463
Thes/niki	Skopje	227	811
Thes/niki	Burgas	587	1596
Constanta	Bucharest	234	739
Constanta	Brasov	365	992
Constanta	Cluj	638	1350
Varna	Burgas	127	452
Varna	Sofia	482	944
Varna	Ruse	191	492

The derived regression equation developed for calculating Euro III heavy duty truck costs per 40ft container is displayed below:

$$y = 1.92x + 241.87$$

Where x represents the distances

Table 8: Purchase prices of heavy duty trucks

Truck Types	Purchase cost	Increase (%)	Freight rate differences (%)
Euro 3 (44t)	30000	-	-
Euro 4 (44t)	40000	33.33	8.33
Euro 5 (44t)	55000	83.33	20.83
Euro 6 (44t)	100000	233.33	58.33

Table 9: Heavy duty truck freight rates

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Thes/niki	Cluj	916	2001	1600	2167	1734	2417	1934	3168	2534
Thes/niki	Brasov	798	1774	1419	1922	1537	2144	1715	2809	2247
Thes/niki	Iasi	1096	2346	1877	2542	2033	2835	2268	3715	2972
Thes/niki	Constanta	874	1920	1536	2080	1664	2320	1856	3040	2432
Thes/niki	Prahova	1196	2538	2031	2750	2200	3067	2454	4019	3215
Thes/niki	Bucharest	692	1571	1256	1701	1361	1898	1518	2487	1989
Thes/niki	Timisoara	737	1657	1326	1795	1436	2002	1602	2623	2099
Thes/niki	Craiova	554	1306	1044	1414	1131	1577	1262	2067	1654
Thes/niki	Skopje	226	676	541	732	586	817	653	1070	856
Thes/niki	Vidin	462	1129	903	1223	978	1364	1091	1787	1430
Thes/niki	Ruse	629	1450	1160	1570	1256	1751	1401	2295	1836
Thes/niki	Varna	711	1607	1286	1741	1393	1942	1553	2544	2035
Thes/niki	Burgas	587	1369	1095	1483	1186	1654	1323	2167	1734
Thes/niki	Plovdiv	355	923	739	1000	800	1116	893	1462	1170
Thes/niki	Sofia	287	793	634	859	687	958	766	1255	1004
Thes/niki	Thes/niki	10	100	80	108	87	121	97	158	127

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Varna	Cluj	681	1549	1240	1678	1343	1872	1498	2453	1963
Varna	Brasov	429	1066	852	1154	923	1288	1030	1687	1350
Varna	Iasi	559	1315	1052	1425	1140	1589	1271	2082	1666
Varna	Constanta	156	541	433	586	469	654	523	857	686
Varna	Prahova	444	1094	875	1186	948	1322	1058	1733	1386
Varna	Bucharest	267	755	604	817	654	912	729	1195	956
Varna	Timisoara	758	1697	1358	1839	1471	2051	1641	2687	2150
Varna	Craiova	489	1181	945	1279	1023	1427	1141	1869	1496
Varna	Skopje	658	1505	1204	1631	1304	1819	1455	2383	1907
Varna	Vidin	521	1242	994	1346	1077	1501	1201	1967	1573
Varna	Ruse	191	609	487	659	527	735	588	964	771
Varna	Varna	10	100	80	108	87	121	97	158	127
Varna	Burgas	127	486	389	526	421	587	470	769	615
Varna	Plovdiv	367	947	757	1025	820	1144	915	1499	1199
Varna	Sofia	483	1169	935	1267	1013	1413	1130	1851	1481
Varna	Thes/niki	711	1607	1286	1741	1393	1942	1553	2544	2035
Constanta	Cluj	638	1467	1173	1589	1271	1772	1418	2322	1858
Constanta	Brasov	365	943	754	1021	817	1139	911	1493	1194
Constanta	Iasi	436	1079	863	1169	935	1304	1043	1708	1367
Constanta	Constanta	10	100	80	108	87	121	97	158	127
Constanta	Prahova	318	852	682	923	739	1030	824	1350	1080
Constanta	Bucharest	234	691	553	749	599	835	668	1094	875
Constanta	Timisoara	749	1680	1344	1820	1456	2030	1624	2660	2128
Constanta	Craiova	454	1114	891	1206	965	1346	1076	1763	1410
Constanta	Skopje	791	1761	1408	1907	1526	2127	1702	2788	2230
Constanta	Vidin	566	1329	1063	1439	1151	1605	1284	2104	1683
Constanta	Ruse	254	730	584	790	632	882	705	1155	924
Constanta	Varna	156	541	433	586	469	654	523	857	686
Constanta	Burgas	285	789	631	855	684	953	763	1249	999
Constanta	Plovdiv	512	1225	980	1327	1062	1480	1184	1939	1552
Constanta	Sofja	570	1336	1069	1448	1158	1615	1292	2116	1693
Constanta	Thes/niki	874	1920	1536	2080	1664	2320	1856	3040	2432

5.2 Delivery truck costs

We consider typical 10 ton delivery trucks with a platform loading capacity of 31 m³ (5 x 2.45 x 2.5). Given delivery truck freight rates (for transporting the estimated payload of 3.2 tons) for various routes in Greece (V.C.H. Kampakis Group, “Personal Communication”), we have formulated a regression equation for calculating delivery truck freight rates per 40ft container, for the option of outsourcing (the initial values were adjusted to delivery truck freight rates per 40ft container by multiplying them by 2.2,

which represents the examined 40ft container and delivery truck, volume capacity ratios, 67/31). For the option that involves leasing of delivery truck transportation services, the same reduction in freight rates is considered with that of heavy duty trucks while Euro IV, V and VI delivery truck freight rates are also estimated based on their purchase cost differences with Euro III. Table 10 represents the estimated Euro III delivery truck freight rates per 40ft container in the regions of Greece, while table 11 the purchase costs of Euro IV, V, VI and the percentage purchase cost differences and freight rates with Euro III (S.Savatis LTD). Finally table 12 displays the delivery truck freight rates in the examined routes.

Table 10: Euro III delivery truck freight rates

From	to	Distance (kms)	Cost per 40ft container
Thes/niki	Athens	500	2844
Thes/niki	Xanthi	223	2559
Thes/niki	Kozani	130	2275
Thes/niki	Kilkis	50	1877

The derived regression equation developed for calculating Euro III delivery truck costs per 40ft container is displayed below:

$$y = 1.953x + 1948$$

Table 11: Purchase prices of delivery trucks

Truck Types	Purchase cost	Increase (%)	Freight rate differences (%)
Euro 3 (10ton)	15000	-	-
Euro 4 (10ton)	20000	0.33	8.3
Euro 5 (10ton)	25000	0.67	16.8
Euro 6 (10ton)	60000	3.00	75.0

Table 12: Delivery truck freight rates

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	Kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Cluj	Cluj	10	220	176	238	191	257	206	385	308
Cluj	Brasov	272	2479	1983	2685	2148	2896	2317	4339	3471
Cluj	Iasi	374	2678	2143	2901	2321	3128	2503	4687	3750
Cluj	Constanta	638	3194	2555	3459	2767	3731	2984	5590	4472
Cluj	Prahova	364	2659	2127	2880	2304	3106	2484	4653	3722
Cluj	Bucharest	421	2770	2216	3000	2400	3236	2588	4848	3878
Cluj	Timisoara	317	2567	2054	2780	2224	2998	2399	4492	3594
Cluj	Craiova	342	2616	2093	2833	2266	3055	2444	4578	3662
Cluj	Skopje	764	3440	2752	3726	2980	4018	3214	6020	4816
Cluj	Vidin	455	2837	2269	3072	2458	3313	2651	4964	3971
Cluj	Ruse	486	2897	2318	3138	2510	3384	2707	5070	4056
Cluj	Varna	681	3278	2622	3550	2840	3829	3063	5736	4589
Cluj	Burgas	731	3376	2701	3656	2925	3943	3154	5907	4726

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Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	Kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Cluj	Plovdiv	747	3407	2726	3690	2952	3979	3183	5962	4770
Cluj	Sofia	621	3161	2529	3423	2739	3692	2953	5531	4425
Brasov	Cluj	272	2479	1983	2685	2148	2896	2317	4339	3471
Brasov	Brasov	10	220	176	238	191	257	206	385	308
Brasov	Iasi	292	2518	2015	2727	2182	2941	2353	4407	3526
Brasov	Constanta	365	2661	2129	2882	2305	3108	2486	4656	3725
Brasov	Prahova	94	2132	1705	2309	1847	2490	1992	3730	2984
Brasov	Bucharest	160	2260	1808	2448	1958	2640	2112	3956	3165
Brasov	Timisoara	409	2747	2197	2975	2380	3208	2567	4807	3845
Brasov	Craiova	265	2466	1972	2670	2136	2880	2304	4315	3452
Brasov	Skopje	690	3296	2636	3569	2855	3849	3079	5767	4614
Brasov	Vidin	362	2655	2124	2875	2300	3101	2481	4646	3717
Brasov	Ruse	236	2409	1927	2609	2087	2814	2251	4216	3372
Brasov	Varna	429	2786	2229	3017	2414	3254	2603	4875	3900
Brasov	Burgas	478	2882	2305	3121	2497	3366	2693	5043	4034
Brasov	Plovdiv	509	2942	2354	3186	2549	3436	2749	5149	4119
Brasov	Sofia	489	2903	2322	3144	2515	3391	2713	5080	4064
Iasi	Cluj	374	2678	2143	2901	2321	3128	2503	4687	3750
Iasi	Brasov	292	2518	2015	2727	2182	2941	2353	4407	3526
Iasi	Iasi	10	220	176	238	191	257	206	385	308
Iasi	Constanta	436	2800	2240	3032	2425	3270	2616	4899	3919
Iasi	Prahova	367	2665	2132	2886	2309	3112	2490	4663	3731
Iasi	Bucharest	396	2721	2177	2947	2358	3179	2543	4762	3810
Iasi	Timisoara	678	3272	2618	3544	2835	3822	3057	5726	4581
Iasi	Craiova	545	3012	2410	3262	2610	3518	2815	5272	4217
Iasi	Skopje	982	3866	3093	4187	3349	4515	3612	6765	5412
Iasi	Vidin	632	3182	2546	3446	2757	3717	2974	5569	4455
Iasi	Ruse	467	2860	2288	3097	2478	3341	2672	5005	4004
Iasi	Varna	559	3040	2432	3292	2634	3550	2840	5320	4256
Iasi	Burgas	640	3198	2558	3463	2771	3735	2988	5596	4477
Iasi	Plovdiv	725	3364	2691	3643	2915	3929	3143	5887	4709
Iasi	Sofia	764	3440	2752	3726	2980	4018	3214	6020	4816
Constanta	Cluj	638	3194	2555	3459	2767	3731	2984	5590	4472
Constanta	Brasov	365	2661	2129	2882	2305	3108	2486	4656	3725
Constanta	Iasi	436	2800	2240	3032	2425	3270	2616	4899	3919
Constanta	Constanta	10	220	176	238	191	257	206	385	308
Constanta	Prahova	318	2569	2055	2782	2226	3001	2401	4496	3597
Constanta	Bucharest	234	2405	1924	2605	2084	2809	2247	4209	3367
Constanta	Timisoara	749	3411	2729	3694	2955	3984	3187	5969	4775

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	Kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Constanta	Craiova	454	2835	2268	3070	2456	3311	2649	4961	3969
Constanta	Skopje	791	3493	2794	3783	3026	4080	3264	6112	4890
Constanta	Vidin	566	3053	2443	3307	2645	3566	2853	5343	4275
Constanta	Ruse	254	2444	1955	2647	2118	2855	2284	4277	3422
Constanta	Varna	156	2253	1802	2440	1952	2631	2105	3942	3154
Constanta	Burgas	285	2505	2004	2712	2170	2925	2340	4383	3506
Constanta	Plovdiv	512	2948	2358	3193	2554	3443	2755	5159	4127
Constanta	Sofia	570	3061	2449	3315	2652	3575	2860	5357	4286
Prahova	Cluj	364	2659	2127	2880	2304	3106	2484	4653	3722
Prahova	Brasov	94	2132	1705	2309	1847	2490	1992	3730	2984
Prahova	Iasi	367	2665	2132	2886	2309	3112	2490	4663	3731
Prahova	Constanta	318	2569	2055	2782	2226	3001	2401	4496	3597
Prahova	Prahova	10	220	176	238	191	257	206	385	308
Prahova	Bucharest	92	2128	1702	2304	1843	2485	1988	3723	2979
Prahova	Timisoara	508	2940	2352	3184	2547	3434	2747	5145	4116
Prahova	Craiova	265	2466	1972	2670	2136	2880	2304	4315	3452
Prahova	Skopje	737	3387	2710	3669	2935	3956	3165	5928	4742
Prahova	Vidin	361	2653	2122	2873	2299	3099	2479	4643	3714
Prahova	Ruse	624	3167	2533	3430	2744	3699	2959	5542	4433
Prahova	Varna	444	2815	2252	3049	2439	3288	2630	4926	3941
Prahova	Burgas	559	3040	2432	3292	2634	3550	2840	5320	4256
Prahova	Plovdiv	824	3557	2846	3853	3082	4155	3324	6225	4980
Prahova	Sofia	558	3038	2430	3290	2632	3548	2838	5316	4253
Bucharest	Cluj	421	2770	2216	3000	2400	3236	2588	4848	3878
Bucharest	Brasov	160	2260	1808	2448	1958	2640	2112	3956	3165
Bucharest	Iasi	396	2721	2177	2947	2358	3179	2543	4762	3810
Bucharest	Constanta	234	2405	1924	2605	2084	2809	2247	4209	3367
Bucharest	Prahova	92	2128	1702	2304	1843	2485	1988	3723	2979
Bucharest	Bucharest	10	220	176	238	191	257	206	385	308
Bucharest	Timisoara	502	2928	2343	3171	2537	3420	2736	5125	4100
Bucharest	Craiova	233	2403	1922	2603	2082	2807	2245	4205	3364
Bucharest	Skopje	599	3118	2494	3377	2701	3642	2913	5456	4365
Bucharest	Vidin	329	2591	2072	2806	2244	3026	2421	4533	3627
Bucharest	Ruse	74	2093	1674	2266	1813	2444	1955	3662	2930
Bucharest	Varna	267	2469	1976	2674	2140	2884	2307	4322	3457
Bucharest	Burgas	317	2567	2054	2780	2224	2998	2399	4492	3594
Bucharest	Plovdiv	328	2589	2071	2803	2243	3023	2419	4530	3624
Bucharest	Sofia	374	2678	2143	2901	2321	3128	2503	4687	3750
Timisoara	Cluj	317	2567	2054	2780	2224	2998	2399	4492	3594

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	Kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Timisoara	Brasov	409	2747	2197	2975	2380	3208	2567	4807	3845
Timisoara	Iasi	678	3272	2618	3544	2835	3822	3057	5726	4581
Timisoara	Constanta	749	3411	2729	3694	2955	3984	3187	5969	4775
Timisoara	Prahova	508	2940	2352	3184	2547	3434	2747	5145	4116
Timisoara	Bucharest	502	2928	2343	3171	2537	3420	2736	5125	4100
Timisoara	Timisoara	10	220	176	238	191	257	206	385	308
Timisoara	Craiova	317	2567	2054	2780	2224	2998	2399	4492	3594
Timisoara	Skopje	586	3092	2474	3349	2679	3612	2890	5412	4329
Timisoara	Vidin	306	2546	2036	2757	2206	2973	2379	4455	3564
Timisoara	Ruse	567	3055	2444	3309	2647	3569	2855	5347	4277
Timisoara	Varna	758	3428	2743	3713	2970	4004	3203	6000	4800
Timisoara	Burgas	801	3512	2810	3804	3043	4102	3282	6147	4917
Timisoara	Plovdiv	694	3303	2643	3578	2862	3858	3087	5781	4625
Timisoara	Sofia	499	2923	2338	3165	2532	3414	2731	5114	4092
Craiova	Cluj	342	2616	2093	2833	2266	3055	2444	4578	3662
Craiova	Brasov	266	2467	1974	2672	2138	2882	2306	4318	3454
Craiova	Iasi	545	3012	2410	3262	2610	3518	2815	5272	4217
Craiova	Constanta	454	2835	2268	3070	2456	3311	2649	4961	3969
Craiova	Prahova	265	2466	1972	2670	2136	2880	2304	4315	3452
Craiova	Bucharest	233	2403	1922	2603	2082	2807	2245	4205	3364
Craiova	Timisoara	317	2567	2054	2780	2224	2998	2399	4492	3594
Craiova	Craiova	10	220	176	238	191	257	206	385	308
Craiova	Skopje	448	2823	2258	3057	2446	3297	2638	4940	3952
Craiova	Vidin	96	2135	1708	2313	1850	2494	1995	3737	2990
Craiova	Ruse	232	2401	1921	2600	2080	2804	2244	4202	3362
Craiova	Varna	489	2903	2322	3144	2515	3391	2713	5080	4064
Craiova	Burgas	485	2895	2316	3136	2508	3382	2705	5067	4053
Craiova	Plovdiv	371	2673	2138	2894	2316	3122	2497	4677	3742
Craiova	Sofia	245	2426	1941	2628	2102	2834	2267	4246	3397
Skopje	Cluj	764	3440	2752	3726	2980	4018	3214	6020	4816
Skopje	Brasov	690	3296	2636	3569	2855	3849	3079	5767	4614
Skopje	Iasi	982	3866	3093	4187	3349	4515	3612	6765	5412
Skopje	Constanta	791	3493	2794	3783	3026	4080	3264	6112	4890
Skopje	Prahova	737	3387	2710	3669	2935	3956	3165	5928	4742
Skopje	Bucharest	599	3118	2494	3377	2701	3642	2913	5456	4365
Skopje	Timisoara	586	3092	2474	3349	2679	3612	2890	5412	4329
Skopje	Craiova	448	2823	2258	3057	2446	3297	2638	4940	3952
Skopje	Skopje	10	220	176	238	191	257	206	385	308
Skopje	Vidin	352	2635	2108	2854	2283	3078	2463	4612	3690

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	Kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Skopje	Ruse	557	3036	2429	3288	2630	3546	2837	5313	4250
Skopje	Varna	658	3233	2586	3501	2801	3776	3021	5658	4526
Skopje	Burgas	620	3159	2527	3421	2737	3690	2952	5528	4422
Skopje	Plovdiv	364	2659	2127	2880	2304	3106	2484	4653	3722
Skopje	Sofia	225	2387	1910	2586	2068	2789	2231	4178	3342
Vidin	Cluj	455	2837	2269	3072	2458	3313	2651	4964	3971
Vidin	Brasov	362	2655	2124	2875	2300	3101	2481	4646	3717
Vidin	Iasi	632	3182	2546	3446	2757	3717	2974	5569	4455
Vidin	Constanta	566	3053	2443	3307	2645	3566	2853	5343	4275
Vidin	Prahova	361	2653	2122	2873	2299	3099	2479	4643	3714
Vidin	Bucharest	329	2591	2072	2806	2244	3026	2421	4533	3627
Vidin	Timisoara	306	2546	2036	2757	2206	2973	2379	4455	3564
Vidin	Craiova	96	2135	1708	2313	1850	2494	1995	3737	2990
Vidin	Skopje	352	2635	2108	2854	2283	3078	2463	4612	3690
Vidin	Vidin	10	220	176	238	191	257	206	385	308
Vidin	Ruse	341	2614	2091	2831	2265	3053	2442	4574	3660
Vidin	Varna	521	2966	2372	3212	2569	3464	2771	5190	4152
Vidin	Burgas	613	3145	2516	3406	2725	3674	2939	5504	4403
Vidin	Plovdiv	359	2649	2119	2869	2295	3094	2475	4636	3709
Vidin	Sofia	187	2313	1851	2505	2004	2702	2161	4048	3238
Ruse	Cluj	302	2538	2030	2748	2199	2964	2371	4441	3553
Ruse	Brasov	236	2409	1927	2609	2087	2814	2251	4216	3372
Ruse	Iasi	467	2860	2288	3097	2478	3341	2672	5005	4004
Ruse	Constanta	254	2444	1955	2647	2118	2855	2284	4277	3422
Ruse	Prahova	624	3167	2533	3430	2744	3699	2959	5542	4433
Ruse	Bucharest	74	2093	1674	2266	1813	2444	1955	3662	2930
Ruse	Timisoara	567	3055	2444	3309	2647	3569	2855	5347	4277
Ruse	Craiova	232	2401	1921	2600	2080	2804	2244	4202	3362
Ruse	Skopje	557	3036	2429	3288	2630	3546	2837	5313	4250
Ruse	Vidin	341	2614	2091	2831	2265	3053	2442	4574	3660
Ruse	Ruse	10	220	176	238	191	257	206	385	308
Ruse	Varna	191	2321	1857	2514	2011	2711	2169	4062	3249
Ruse	Burgas	245	2426	1941	2628	2102	2834	2267	4246	3397
Ruse	Plovdiv	256	2448	1958	2651	2121	2859	2287	4284	3427
Ruse	Sofia	302	2538	2030	2748	2199	2964	2371	4441	3553
Varna	Cluj	681	3278	2622	3550	2840	3829	3063	5736	4589
Varna	Brasov	429	2786	2229	3017	2414	3254	2603	4875	3900
Varna	Iasi	559	3040	2432	3292	2634	3550	2840	5320	4256
Varna	Constanta	156	2253	1802	2440	1952	2631	2105	3942	3154

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Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	Kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Varna	Prahova	444	2815	2252	3049	2439	3288	2630	4926	3941
Varna	Bucharest	267	2469	1976	2674	2140	2884	2307	4322	3457
Varna	Timisoara	758	3428	2743	3713	2970	4004	3203	6000	4800
Varna	Craiova	489	2903	2322	3144	2515	3391	2713	5080	4064
Varna	Skopje	658	3233	2586	3501	2801	3776	3021	5658	4526
Varna	Vidin	521	2966	2372	3212	2569	3464	2771	5190	4152
Varna	Ruse	191	2321	1857	2514	2011	2711	2169	4062	3249
Varna	Varna	10	220	176	238	191	257	206	385	308
Varna	Burgas	127	2196	1757	2378	1903	2565	2052	3843	3074
Varna	Plovdiv	367	2665	2132	2886	2309	3112	2490	4663	3731
Varna	Sofia	483	2891	2313	3131	2505	3377	2702	5060	4048
Burgas	Cluj	731	3376	2701	3656	2925	3943	3154	5907	4726
Burgas	Brasov	478	2882	2305	3121	2497	3366	2693	5043	4034
Burgas	Iasi	640	3198	2558	3463	2771	3735	2988	5596	4477
Burgas	Constanta	285	2505	2004	2712	2170	2925	2340	4383	3506
Burgas	Prahova	559	3040	2432	3292	2634	3550	2840	5320	4256
Burgas	Bucharest	317	2567	2054	2780	2224	2998	2399	4492	3594
Burgas	Timisoara	801	3512	2810	3804	3043	4102	3282	6147	4917
Burgas	Craiova	485	2895	2316	3136	2508	3382	2705	5067	4053
Burgas	Skopje	620	3159	2527	3421	2737	3690	2952	5528	4422
Burgas	Vidin	613	3145	2516	3406	2725	3674	2939	5504	4403
Burgas	Ruse	245	2426	1941	2628	2102	2834	2267	4246	3397
Burgas	Varna	124	2190	1752	2372	1898	2558	2046	3833	3066
Burgas	Burgas	10	220	176	238	191	257	206	385	308
Burgas	Plovdiv	270	2475	1980	2681	2145	2891	2313	4332	3465
Burgas	Sofia	401	2731	2185	2958	2366	3190	2552	4780	3824
Plovdiv	Cluj	753	3419	2735	3702	2962	3993	3194	5983	4786
Plovdiv	Brasov	509	2942	2354	3186	2549	3436	2749	5149	4119
Plovdiv	Iasi	725	3364	2691	3643	2915	3929	3143	5887	4709
Plovdiv	Constanta	512	2948	2358	3193	2554	3443	2755	5159	4127
Plovdiv	Prahova	824	3557	2846	3853	3082	4155	3324	6225	4980
Plovdiv	Bucharest	328	2589	2071	2803	2243	3023	2419	4530	3624
Plovdiv	Timisoara	694	3303	2643	3578	2862	3858	3087	5781	4625
Plovdiv	Craiova	371	2673	2138	2894	2316	3122	2497	4677	3742
Plovdiv	Skopje	364	2659	2127	2880	2304	3106	2484	4653	3722
Plovdiv	Vidin	359	2649	2119	2869	2295	3094	2475	4636	3709
Plovdiv	Ruse	256	2448	1958	2651	2121	2859	2287	4284	3427
Plovdiv	Varna	367	2665	2132	2886	2309	3112	2490	4663	3731
Plovdiv	Burgas	270	2475	1980	2681	2145	2891	2313	4332	3465

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	Kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Plovdiv	Plovdiv	10	220	176	238	191	257	206	385	308
Plovdiv	Sofia	140	2221	1777	2406	1925	2595	2076	3887	3110
Sofia	Cluj	621	3161	2529	3423	2739	3692	2953	5531	4425
Sofia	Brasov	489	2903	2322	3144	2515	3391	2713	5080	4064
Sofia	Iasi	764	3440	2752	3726	2980	4018	3214	6020	4816
Sofia	Constanta	570	3061	2449	3315	2652	3575	2860	5357	4286
Sofia	Prahova	558	3038	2430	3290	2632	3548	2838	5316	4253
Sofia	Bucharest	374	2678	2143	2901	2321	3128	2503	4687	3750
Sofia	Timisoara	499	2923	2338	3165	2532	3414	2731	5114	4092
Sofia	Craiova	245	2426	1941	2628	2102	2834	2267	4246	3397
Sofia	Skopje	225	2387	1910	2586	2068	2789	2231	4178	3342
Sofia	Vidin	187	2313	1851	2505	2004	2702	2161	4048	3238
Sofia	Ruse	302	2538	2030	2748	2199	2964	2371	4441	3553
Sofia	Varna	483	2891	2313	3131	2505	3377	2702	5060	4048
Sofia	Burgas	401	2731	2185	2958	2366	3190	2552	4780	3824
Sofia	Plovdiv	140	2221	1777	2406	1925	2595	2076	3887	3110
Sofia	Sofia	10	220	176	238	191	257	206	385	308
Thes/niki	Cluj	916	3737	2990	4047	3238	4365	3492	6540	5232
Thes/niki	Brasov	798	3506	2805	3798	3038	4096	3276	6136	4909
Thes/niki	Iasi	1096	4088	3271	4428	3542	4775	3820	7155	5724
Thes/niki	Constanta	874	3655	2924	3958	3167	4269	3415	6396	5117
Thes/niki	Prahova	1196	4284	3427	4639	3711	5003	4003	7497	5997
Thes/niki	Bucharest	692	3299	2640	3573	2859	3854	3083	5774	4619
Thes/niki	Timisoara	737	3387	2710	3669	2935	3956	3165	5928	4742
Thes/niki	Craiova	554	3030	2424	3281	2625	3539	2831	5302	4242
Thes/niki	Skopje	226	2389	1912	2588	2070	2791	2233	4181	3345
Thes/niki	Vidin	462	2850	2280	3087	2469	3329	2663	4988	3990
Thes/niki	Ruse	629	3176	2541	3440	2752	3710	2968	5559	4447
Thes/niki	Varna	711	3337	2669	3614	2891	3897	3118	5839	4671
Thes/niki	Burgas	587	3094	2476	3351	2681	3614	2891	5415	4332
Thes/niki	Plovdiv	355	2641	2113	2861	2288	3085	2468	4622	3698
Thes/niki	Sofia	287	2509	2007	2717	2173	2930	2344	4390	3512

5.3 Rail costs

Rail costs incorporate (i) the rail freight rate for transporting a 40ft container to its destinations rail depot (ii) the rail freight rate for returning the empty 40ft container (iii) the handling costs at the rail freight depot and (v) the city limit expenses for transporting a 40ft container by truck from the rail depot to its final destination and returning the empty. The parameters required for calculating the rail freight rates per 40ft container incorporate (i) rail freight rate coefficients set, based on different gross weights and types

of containers and (ii) rail freight rate coefficients set, based on the distances of specific routes. These coefficients are then multiplied in order to derive the rail freight rate per 40ft container in the examined routes. The same methodology is adopted for calculating the rail freight rate for returning the empty 40ft container. In this case the first coefficient is the one that corresponds to the lowest 40ft container gross weight category while the second remains same. Finally for every 15 x 40ft containers a block train is deployed that results in a 20% discount compared to the rail freight rates for transporting an individual 40ft container.

Table 13 displays the gross weight and size classification coefficients, while table 14 the additional rail transportation related costs. Finally, table 15 displays the rail and block train freight rates per 40ft container. All data displayed in the following tables have been retrieved from the Greek Railway organizations price lists (TRAINOSE),

Table 13: Weight and size classification coefficients

Container type	Gross weight (g.w.)	Coefficient
20 foot	$g.w. \leq 8t$	0.37
	$8t \leq g.w. \leq 16.5t$	0.45
	$16t \leq g.w. \leq 22.0t$	0.55
	$22t \leq g.w. \leq 34.0t$	0.75
	$34t \leq g.w.$	0.85
40 foot	$g.w. \leq 8t$	0.70
	$8t \leq g.w. \leq 16.5t$	0.75
	$16t \leq g.w. \leq 22.0t$	1.00
	$22t \leq g.w. \leq 34.0t$	1.00
	$34t \leq g.w.$	1.00

Since 40ft containers with a gross weight of 11 tons are considered in this work the weight, size classification coefficient used is 0.75 while the size and weight classification coefficient considered for returning the empty is 0.70

Table 14: Distance coefficients

Cost Breakdown	Cost in €
Handling costs per 40ft container	50
City limit expenses	100
Total costs	150

Table 15: Rail and block train freight rates per 40ft container

From	To	rail	block train
Thes/niki	Cluj	2087	1700
Thes/niki	Brasov	1822	1487
Thes/niki	Iasi	2042	1664
Thes/niki	Constanta	2009	1637
Thes/niki	Prahova	heavy duty truck transportation	
Thes/niki	Bucharest	1696	1387

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From	To	rail	block train
Thes/niki	Timisoara	2042	1664
Thes/niki	Craiova	1878	1533
Thes/niki	Skopje	847	708
Thes/niki	Vidin	1285	1058
Thes/niki	Ruse	1175	970
Thes/niki	Varna	1594	1305
Thes/niki	Burgas	1488	1221
Thes/niki	Plovdiv	810	678
Thes/niki	Sofia	946	787
Thes/niki	Thes/niki	city limit transportation	
Varna	Cluj	1052	872
Varna	Brasov	787	659
Varna	Iasi	1007	836
Varna	Constanta	974	1769
Varna	Prahova	heavy duty truck transportation	
Varna	Bucharest	660	558
Varna	Timisoara	1007	836
Varna	Craiova	843	704
Varna	Skopje	9999	17629
Varna	Vidin	1142	943
Varna	Ruse	624	529
Varna	Varna	city limit transportation	
Varna	Burgas	998	829
Varna	Plovdiv	1088	901
Varna	Sofia	752	631
Varna	Thes/niki	1594	1305
Constanta	Cluj	1269	1046
Constanta	Brasov	1004	833
Constanta	Iasi	1224	1010
Constanta	Constanta	city limit transportation	
Constanta	Prahova	heavy duty truck transportation	
Constanta	Bucharest	878	732
Constanta	Timisoara	1269	1046
Constanta	Craiova	1061	878
Constanta	Skopje	heavy duty truck transportation	
Constanta	Vidin	974	1769
Constanta	Ruse	671	566
Constanta	Varna	974	1769
Constanta	Burgas	1139	941
Constanta	Plovdiv	1090	902

From	To	rail	block train
Constanta	Sofia	1124	930
Constanta	Thes	2009	1637

At this point we must state that no rail depot operates in Prahova and therefore rail transportation is not considered as an option. Additionally for Skopje and considering that there are no direct rail connections between Bulgarian, Romanian and Skopje rail depots we assume that the Distribution Center of Skopje is served by the Entry Points of Varna and Constanta by heavy duty trucks solely.

5.4 Shipping Costs

The shipping costs examined in this case study incorporate: (i) a sea freight rate per 40ft container from Shanghai to Thes/niki, Varna and Constanta respectively (ii) local charges per 40ft container at each Port of destination and (iii) a custom clearance cost per 40ft container. The cost data displayed in table 16 have been also estimated based on shipping costs per TEU, retrieved from Orphee Beinoglou INTL Forwarders S.A, (while considering a 33% increase as in heavy duty trucks freight rates). At this point we must state that the ship freight rates considered may change significantly due to the extremely volatile shipping freight market.

Table 16: Shipping costs per 40ft container in (€)

Cost break down	Thes/niki	Varna	Constanta
Freight rates	1898	2076	2136
Local charges	219	279	271
Custom clearance	200	266	200
Total	2317	2621	2607

6 Transportation Emissions

The transportation emissions calculated in this subsection encapsulate (i) the examined container vessels CO₂ and PM emissions (ii) Euro III, IV, V, VI heavy duty and delivery truck CO₂ and PM emissions and (iii) diesel rail CO₂ and PM emissions.

6.1 Euro III, IV, V, VI heavy duty and delivery truck CO₂ and PM emissions

Euro III heavy duty and delivery truck CO₂ and PM emissions are calculated based on fixed CO₂ and PM emission amounts (Boer, et al., 2008). To be more specific approximately 847 and 0.32 gr/km of CO₂ and PM emissions are produced respectively for heavy duty trucks and 429, 0.28 gr/km for delivery trucks. The same CO₂ emissions amounts will be considered for Euro IV, V, and VI heavy duty and delivery trucks since different Euro-type engines have no effect in terms of CO₂ emissions generated. Regarding PM emissions though, there are significant percentage reductions between Euro III and IV as also Euro V and VI engine types respectively. For the options that involves outsourcing of transportation services the company is not accountable for the PM and CO₂ emissions generated in the return trips of the heavy duty and delivery trucks, since the latter are typically utilized to transport cargo for other companies returning. Therefore the amount of emissions generated in the return haul of the trip will not be considered. On the other hand though the leased heavy duty and delivery trucks are dedicated to serve the examined company, therefore the amount of emissions generated by the empty truck on the return trip will be aggregated. Regarding return emissions and given specific payloads, the fuel consumption of the heavy duty trucks utilized in this work is estimated to decrease by approximately 30% (Coyle. M. 2007). For delivery trucks we consider a 40% difference since the tonnage of the cargo transported represents a

higher percentage of the empty trucks weight compared to heavy duty trucks. Table 17 presents the PM emissions standards for different heavy duty Euro engines. We consider the same emission standards for the medium to heavy duty delivery trucks (10tons) utilized in this work. Table 18 provides fuel consumption data for 44t heavy duty trucks given different payloads while Tables 19 and 20 display the PM and CO₂ emissions performance of different Euro type heavy duty and delivery trucks respectively. Tables 21 and 22 present Euro III heavy duty truck CO₂ emissions and Euro III, IV, V and VI heavy duty truck PM emissions respectively, for the options of outsourcing and leasing. Finally tables 23 and 24 display the CO₂ emissions performance of Euro III delivery trucks, and the PM emissions performance of Euro III, IV, V and VI delivery trucks respectively for the options of outsourcing and leasing.

Table 17: PM emissions standards

Euro types	PMs	Ratio
Euro III	0.1	100%
Euro IV	0.02	20%
Euro V	0.02	20%
Euro VI	0.01	10%

Table 18: Fuel consumption of 44t trucks given different loads

Loads	Consumption l/t/km
Empty (15.76 tons)	0.017
26 tons gross (our truck)	0.015
32 tons gross	0.014
44 tons gross	0.012

Table 19: Euro type heavy duty truck emissions

Euro norm	CO₂ gr/km (full)	CO₂ gr/km (empty)	PM gr/km (full)	PM gr/km (empty)
Euro III	847.0	593.0	0.320	0.2240
Euro IV	847.0	593.0	0.064	0.0448
Euro V	847.0	593.0	0.064	0.0448
Euro VI	847.0	593.0	0.032	0.0224

Table 20: Euro type delivery truck emissions

Truck Type	CO₂ gr/km (full)	CO₂ gr/km (empty)	PM gr/km (full)	PM gr/km (empty)
Euro III	943.8	566.28	0.616	0.370
Euro IV	943.8	566.28	0.123	0.074
Euro V	943.8	566.28	0.123	0.074
Euro VI	943.8	566.28	0.062	0.037

Table 21: Euro III heavy duty truck CO₂ emissions (kg)

Nodes		Dist.	Euro III heavy duty	
From	To	kms	Outsourcing	Leasing

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Nodes		Dist.	Euro III heavy duty	
From	To	kms	Outsourcing	Leasing
Thes/niki	Cluj	916	776	1319
Thes/niki	Brasov	798	676	1149
Thes/niki	Iasi	1096	928	1578
Thes/niki	Constanta	874	740	1258
Thes/niki	Prahova	1196	1013	1722
Thes/niki	Bucharest	692	586	996
Thes/niki	Timisoara	737	624	1061
Thes/niki	Craiova	554	469	798
Thes/niki	Skopje	226	191	325
Thes/niki	Vidin	462	391	665
Thes/niki	Ruse	629	533	906
Thes/niki	Varna	711	602	1024
Thes/niki	Burgas	587	497	845
Thes/niki	Plovdiv	355	301	511
Thes/niki	Sofia	287	243	413
Thes/niki	Thes/niki	10	8	14
Varna	Cluj	681	577	981
Varna	Brasov	429	363	618
Varna	Iasi	559	473	805
Varna	Constanta	156	132	225
Varna	Prahova	444	376	639
Varna	Bucharest	267	226	384
Varna	Timisoara	758	642	1091
Varna	Craiova	489	414	704
Varna	Skopje	658	557	947
Varna	Vidin	521	441	750
Varna	Ruse	191	162	275
Varna	Varna	10	8	14
Varna	Burgas	127	108	183
Varna	Plovdiv	367	311	528
Varna	Sofia	483	409	695
Varna	Thes/niki	711	602	1024
Constanta	Cluj	638	540	919
Constanta	Brasov	365	309	526
Constanta	Iasi	436	369	628
Constanta	Constanta	10	8	14
Constanta	Prahova	318	269	458
Constanta	Bucharest	234	198	337
Constanta	Timisoara	749	634	1078

Nodes		Dist.	Euro III heavy duty	
From	To	kms	Outsourcing	Leasing
Constanta	Craiova	454	385	654
Constanta	Skopje	791	670	1139
Constanta	Vidin	566	479	815
Constanta	Ruse	254	215	366
Constanta	Varna	156	132	225
Constanta	Burgas	285	241	410
Constanta	Plovdiv	512	434	737
Constanta	Sofia	570	483	821
Constanta	Thes/niki	874	740	1258

Table 22: Euro type heavy duty truck PM emissions(grams) in the examined routes (leasing &outsourcing)

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Thes/niki	Cluj	916	293.1	498.3	58.6	99.7	58.6	99.7	29.3	49.8
Thes/niki	Brasov	798	255.4	434.1	51.1	86.8	51.1	86.8	25.5	43.4
Thes/niki	Iasi	1096	350.7	596.2	70.1	119.2	70.1	119.2	35.1	59.6
Thes/niki	Constanta	874	279.7	475.5	55.9	95.1	55.9	95.1	28.0	47.5
Thes/niki	Prahova	1196	382.7	650.6	76.5	130.1	76.5	130.1	38.3	65.1
Thes/niki	Bucharest	692	221.4	376.4	44.3	75.3	44.3	75.3	22.1	37.6
Thes/niki	Timisoara	737	235.8	400.9	47.2	176.2	47.2	176.2	23.6	40.1
Thes/niki	Craiova	554	177.3	301.4	35.5	60.3	35.5	60.3	17.7	30.1
Thes/niki	Skopje	226	72.3	122.9	14.5	24.6	14.5	24.6	7.2	12.3
Thes/niki	Vidin	462	147.8	251.3	29.6	50.3	29.6	50.3	14.8	25.1
Thes/niki	Ruse	629	201.3	342.2	40.3	68.4	40.3	68.4	20.1	34.2
Thes/niki	Varna	711	227.5	386.8	45.5	77.4	45.5	77.4	22.8	38.7
Thes/niki	Burgas	587	187.8	319.3	37.6	63.9	37.6	63.9	18.8	31.9
Thes/niki	Plovdiv	355	113.6	193.1	22.7	38.6	22.7	38.6	11.4	19.3
Thes/niki	Sofia	287	91.8	156.1	18.4	31.2	18.4	31.2	9.2	15.6
Thes/niki	Thes/niki	10	3.2	5.4	0.6	1.1	0.6	1.1	0.3	0.5
Varna	Cluj	681	217.9	370.5	43.6	74.1	43.6	74.1	21.8	37.0
Varna	Brasov	429	137.3	233.4	27.5	46.7	27.5	46.7	13.7	23.3
Varna	Iasi	559	178.9	304.1	35.8	60.8	35.8	60.8	17.9	30.4
Varna	Constanta	156	49.9	84.9	10.0	17.0	10.0	17.0	5.0	8.5
Varna	Prahova	444	142.1	241.5	28.4	48.3	28.4	48.3	14.2	24.2
Varna	Bucharest	267	85.4	145.2	17.1	29.0	17.1	29.0	8.5	14.5
Varna	Timisoara	758	242.6	412.4	48.5	82.5	48.5	82.5	24.3	41.2
Varna	Craiova	489	156.5	266.0	31.3	53.2	31.3	53.2	15.6	26.6
Varna	Skopje	658	210.6	358.0	42.1	71.6	42.1	71.6	21.1	35.8

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Varna	Vidin	521	166.7	283.4	33.3	56.7	33.3	56.7	16.7	28.3
Varna	Ruse	191	61.1	103.9	12.2	20.8	12.2	20.8	6.1	10.4
Varna	Varna	10	3.2	5.4	0.6	1.1	0.6	1.1	0.3	0.5
Varna	Burgas	127	40.6	69.1	8.1	13.8	8.1	13.8	4.1	6.9
Varna	Plovdiv	367	117.4	199.6	23.5	39.9	23.5	39.9	11.7	20.0
Varna	Sofia	483	154.6	262.8	30.9	52.6	30.9	52.6	15.5	26.3
Varna	Thes/niki	711	227.5	386.8	45.5	77.4	45.5	77.4	22.8	38.7
Constanta	Cluj	638	204.2	347.1	40.8	69.4	40.8	69.4	20.4	34.7
Constanta	Brasov	365	116.8	198.6	23.4	39.7	23.4	39.7	11.7	19.9
Constanta	Iasi	436	139.5	237.2	27.9	47.4	27.9	47.4	14.0	23.7
Constanta	Constanta	10	3.2	5.4	0.6	1.1	0.6	1.1	0.3	0.5
Constanta	Prahova	318	101.8	173.0	20.4	34.6	20.4	34.6	10.2	17.3
Constanta	Bucharest	234	74.9	127.3	15.0	25.5	15.0	25.5	7.5	12.7
Constanta	Timisoara	749	239.7	407.5	47.9	81.5	47.9	81.5	24.0	40.7
Constanta	Craiova	454	145.3	247.0	29.1	49.4	29.1	49.4	14.5	24.7
Constanta	Skopje	791	253.1	430.3	50.6	86.1	50.6	86.1	25.3	43.0
Constanta	Vidin	566	181.1	307.9	36.2	61.6	36.2	61.6	18.1	30.8
Constanta	Ruse	254	81.3	138.2	16.3	27.6	16.3	27.6	8.1	13.8
Constanta	Varna	156	49.9	84.9	10.0	17.0	10.0	17.0	5.0	8.5
Constanta	Burgas	285	91.2	155.0	18.2	31.0	18.2	31.0	9.1	15.5
Constanta	Plovdiv	512	163.8	278.5	32.8	55.7	32.8	55.7	16.4	27.9
Constanta	Sofia	570	182.4	310.1	36.5	62.0	36.5	62.0	18.2	31.0
Constanta	Thes/niki	874	279.7	475.5	55.9	95.1	55.9	95.1	28.0	47.5

Table 23: Euro III delivery truck CO₂ emissions (kg)

Nodes		Dist.	Euro III delivery truck	
From	To	kms	Outsourcing	Leasing
Cluj	Cluj	10	9	15
Cluj	Brasov	272	257	411
Cluj	Iasi	374	353	565
Cluj	Constanta	638	602	963
Cluj	Prahova	364	344	550
Cluj	Bucharest	421	397	636
Cluj	Timisoara	317	299	479
Cluj	Craiova	342	323	516
Cluj	Skopje	764	721	1154
Cluj	Vidin	455	429	687
Cluj	Ruse	486	459	734
Cluj	Varna	681	643	1028
Cluj	Burgas	731	690	1104

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Nodes		Dist.	Euro III delivery truck	
From	To	kms	Outsourcing	Leasing
Cluj	Plovdiv	747	705	1128
Cluj	Sofia	621	586	938
Brasov	Cluj	272	257	411
Brasov	Brasov	10	9	15
Brasov	Iasi	292	276	441
Brasov	Constanta	365	344	551
Brasov	Prahova	94	89	142
Brasov	Bucharest	160	151	242
Brasov	Timisoara	409	386	618
Brasov	Craiova	265	250	400
Brasov	Skopje	690	651	1042
Brasov	Vidin	362	342	547
Brasov	Ruse	236	223	356
Brasov	Varna	429	405	648
Brasov	Burgas	478	451	722
Brasov	Plovdiv	509	4176	769
Brasov	Sofia	489	462	738
Iasi	Cluj	374	353	565
Iasi	Brasov	292	276	441
Iasi	Iasi	10	9	15
Iasi	Constanta	436	411	658
Iasi	Prahova	367	346	554
Iasi	Bucharest	396	374	598
Iasi	Timisoara	678	640	1024
Iasi	Craiova	545	514	823
Iasi	Skopje	982	927	1483
Iasi	Vidin	632	596	954
Iasi	Ruse	467	441	705
Iasi	Varna	559	528	844
Iasi	Burgas	640	604	966
Iasi	Plovdiv	725	684	1095
Iasi	Sofia	764	721	1154
Constanta	Cluj	638	602	963
Constanta	Brasov	365	344	551
Constanta	Iasi	436	411	658
Constanta	Constanta	10	9	15
Constanta	Prahova	318	300	480
Constanta	Bucharest	234	221	353
Constanta	Timisoara	749	707	1131
Constanta	Craiova	454	428	686
Constanta	Skopje	791	747	1194
Constanta	Vidin	566	534	855
Constanta	Ruse	254	240	384
Constanta	Varna	156	147	236
Constanta	Burgas	285	269	430
Constanta	Plovdiv	512	483	773

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Nodes		Dist.	Euro III delivery truck	
From	To	kms	Outsourcing	Leasing
Constanta	Sofia	570	538	861
Prahova	Cluj	364	344	550
Prahova	Brasov	94	89	142
Prahova	Iasi	367	346	554
Prahova	Constanta	318	300	4176
Prahova	Prahova	10	9	15
Prahova	Bucharest	92	87	139
Prahova	Timisoara	508	479	767
Prahova	Craiova	265	250	400
Prahova	Skopje	737	696	1113
Prahova	Vidin	361	341	545
Prahova	Ruse	624	589	942
Prahova	Varna	444	419	670
Prahova	Burgas	559	528	844
Prahova	Plovdiv	824	778	1244
Prahova	Sofia	558	527	843
Bucharest	Cluj	421	397	636
Bucharest	Brasov	160	151	242
Bucharest	Iasi	396	374	598
Bucharest	Constanta	234	221	353
Bucharest	Prahova	92	87	139
Bucharest	Bucharest	10	9	15
Bucharest	Timisoara	502	474	758
Bucharest	Craiova	233	220	352
Bucharest	Skopje	599	565	905
Bucharest	Vidin	329	311	497
Bucharest	Ruse	74	70	112
Bucharest	Varna	267	252	403
Bucharest	Burgas	317	299	479
Bucharest	Plovdiv	328	310	495
Bucharest	Sofia	374	353	565
Timisoara	Cluj	317	299	479
Timisoara	Brasov	409	386	618
Timisoara	Iasi	678	640	1024
Timisoara	Constanta	749	707	1131
Timisoara	Prahova	508	479	767
Timisoara	Bucharest	502	474	758
Timisoara	Timisoara	10	9	15
Timisoara	Craiova	317	299	479
Timisoara	Skopje	586	553	885
Timisoara	Vidin	306	289	462
Timisoara	Ruse	567	535	856
Timisoara	Varna	758	715	1145
Timisoara	Burgas	1761	756	1210
Timisoara	Plovdiv	694	655	1048
Timisoara	Sofia	499	471	754

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Nodes		Dist.	Euro III delivery truck	
From	To	kms	Outsourcing	Leasing
Craiova	Cluj	342	323	516
Craiova	Brasov	266	251	402
Craiova	Iasi	545	514	823
Craiova	Constanta	454	428	686
Craiova	Prahova	265	250	400
Craiova	Bucharest	233	220	352
Craiova	Timisoara	317	299	479
Craiova	Craiova	10	9	15
Craiova	Skopje	448	423	677
Craiova	Vidin	96	91	145
Craiova	Ruse	232	219	350
Craiova	Varna	489	462	738
Craiova	Burgas	485	458	732
Craiova	Plovdiv	371	350	560
Craiova	Sofia	245	231	370
Skopje	Cluj	764	721	1154
Skopje	Brasov	690	651	1042
Skopje	Iasi	982	927	1483
Skopje	Constanta	791	747	1194
Skopje	Prahova	737	696	1113
Skopje	Bucharest	599	565	905
Skopje	Timisoara	586	553	885
Skopje	Craiova	448	423	677
Skopje	Skopje	10	9	15
Skopje	Vidin	352	332	532
Skopje	Ruse	557	526	841
Skopje	Varna	658	621	994
Skopje	Burgas	620	585	936
Skopje	Plovdiv	364	344	550
Skopje	Sofia	225	212	340
Vidin	Cluj	455	429	687
Vidin	Brasov	362	342	547
Vidin	Iasi	632	596	954
Vidin	Constanta	566	534	855
Vidin	Prahova	361	341	545
Vidin	Bucharest	329	311	497
Vidin	Timisoara	306	289	462
Vidin	Craiova	96	91	145
Vidin	Skopje	352	332	532
Vidin	Vidin	10	9	15
Vidin	Ruse	341	322	515
Vidin	Varna	521	492	787
Vidin	Burgas	613	579	926
Vidin	Plovdiv	359	339	542

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Nodes		Dist.	Euro III delivery truck	
From	To	kms	Outsourcing	Leasing
Vidin	Sofia	187	176	282
Ruse	Cluj	302	285	456
Ruse	Brasov	236	223	356
Ruse	Iasi	467	441	705
Ruse	Constanta	254	240	384
Ruse	Prahova	624	589	942
Ruse	Bucharest	74	70	112
Ruse	Timisoara	567	535	856
Ruse	Craiova	232	219	350
Ruse	Skopje	557	526	841
Ruse	Vidin	341	322	515
Ruse	Ruse	10	9	15
Ruse	Varna	191	1176	288
Ruse	Burgas	245	231	370
Ruse	Plovdiv	256	242	387
Ruse	Sofia	302	285	456
Varna	Cluj	681	643	1028
Varna	Brasov	429	405	648
Varna	Iasi	559	528	844
Varna	Constanta	156	147	236
Varna	Prahova	444	419	670
Varna	Bucharest	267	252	403
Varna	Timisoara	758	715	1145
Varna	Craiova	489	462	738
Varna	Skopje	658	621	994
Varna	Vidin	521	492	787
Varna	Ruse	191	1176	288
Varna	Varna	10	9	15
Varna	Burgas	127	120	192
Varna	Plovdiv	367	346	554
Varna	Sofia	483	456	729
Burgas	Cluj	731	690	1104
Burgas	Brasov	478	451	722
Burgas	Iasi	640	604	966
Burgas	Constanta	285	269	430
Burgas	Prahova	559	528	844
Burgas	Bucharest	317	299	479
Burgas	Timisoara	1761	756	1210
Burgas	Craiova	485	458	732
Burgas	Skopje	620	585	936
Burgas	Vidin	613	579	926
Burgas	Ruse	245	231	370
Burgas	Varna	124	117	187
Burgas	Burgas	10	9	15
Burgas	Plovdiv	270	255	408

Nodes		Dist.	Euro III delivery truck	
From	To	kms	Outsourcing	Leasing
Burgas	Sofia	401	379	606
Plovdiv	Cluj	753	711	1137
Plovdiv	Brasov	509	4176	769
Plovdiv	Iasi	725	684	1095
Plovdiv	Constanta	512	483	773
Plovdiv	Prahova	824	778	1244
Plovdiv	Bucharest	328	310	495
Plovdiv	Timisoara	694	655	1048
Plovdiv	Craiova	371	350	560
Plovdiv	Skopje	364	344	550
Plovdiv	Vidin	359	339	542
Plovdiv	Ruse	256	242	387
Plovdiv	Varna	367	346	554
Plovdiv	Burgas	270	255	408
Plovdiv	Plovdiv	10	9	15
Plovdiv	Sofia	140	132	211
Sofia	Cluj	621	586	938
Sofia	Brasov	489	462	738
Sofia	Iasi	764	721	1154
Sofia	Constanta	570	538	861
Sofia	Prahova	558	527	843
Sofia	Bucharest	374	353	565
Sofia	Timisoara	499	471	754
Sofia	Craiova	245	231	370
Sofia	Skopje	225	212	340
Sofia	Vidin	187	176	282
Sofia	Ruse	302	285	456
Sofia	Varna	483	456	729
Sofia	Burgas	401	378	606
Sofia	Plovdiv	140	132	211
Sofia	Sofia	10	9	15

Table 24: PM emissions(grams) for different Euro type delivery trucks (leasing &outsourcing)

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Cluj	Cluj	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Cluj	Brasov	272	167.6	268.1	33.5	53.6	33.5	53.6	16.8	26.8
Cluj	Iasi	374	230.4	368.6	46.1	73.7	46.1	73.7	23.0	36.9
Cluj	Constanta	638	393.0	628.8	78.6	125.8	78.6	125.8	39.3	62.9
Cluj	Prahova	364	224.2	358.8	44.8	71.8	44.8	71.8	22.4	35.9
Cluj	Bucharest	421	259.3	414.9	51.9	83.0	51.9	83.0	25.9	41.5
Cluj	Timisoara	317	195.3	312.4	39.1	62.5	39.1	62.5	19.5	31.2
Cluj	Craiova	342	210.7	337.1	42.1	67.4	42.1	67.4	21.1	33.7

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Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Cluj	Skopje	764	470.6	753.0	94.1	150.6	94.1	150.6	47.1	75.3
Cluj	Vidin	455	2176.3	448.4	56.1	89.7	56.1	89.7	28.0	44.8
Cluj	Ruse	486	299.4	479.0	59.9	95.8	59.9	95.8	29.9	47.9
Cluj	Varna	681	419.5	671.2	83.9	134.2	83.9	134.2	41.9	67.1
Cluj	Burgas	731	450.3	720.5	90.1	144.1	90.1	144.1	45.0	72.0
Cluj	Plovdiv	747	460.2	736.2	92.0	147.2	92.0	147.2	46.0	73.6
Cluj	Sofia	621	382.5	612.1	76.5	122.4	76.5	122.4	38.3	61.2
Brasov	Cluj	272	167.6	268.1	33.5	53.6	33.5	53.6	16.8	26.8
Brasov	Brasov	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Brasov	Iasi	292	179.9	287.8	36.0	57.6	36.0	57.6	18.0	28.8
Brasov	Constanta	365	224.8	359.7	45.0	71.9	45.0	71.9	22.5	36.0
Brasov	Prahova	94	57.9	92.6	11.6	18.5	11.6	18.5	5.8	9.3
Brasov	Bucharest	160	98.6	157.7	19.7	31.5	19.7	31.5	9.9	15.8
Brasov	Timisoara	409	251.9	403.1	50.4	176.6	50.4	176.6	25.2	40.3
Brasov	Craiova	265	163.2	261.2	32.6	52.2	32.6	52.2	16.3	26.1
Brasov	Skopje	690	425.0	6176.1	85.0	136.0	85.0	136.0	42.5	68.0
Brasov	Vidin	362	223.0	356.8	44.6	71.4	44.6	71.4	22.3	35.7
Brasov	Ruse	236	145.4	232.6	29.1	46.5	29.1	46.5	14.5	23.3
Brasov	Varna	429	264.3	422.8	52.9	84.6	52.9	84.6	26.4	42.3
Brasov	Burgas	478	294.4	471.1	58.9	94.2	58.9	94.2	29.4	47.1
Brasov	Plovdiv	509	313.5	501.7	62.7	100.3	62.7	100.3	31.4	50.2
Brasov	Sofia	489	301.2	482.0	60.2	96.4	60.2	96.4	30.1	48.2
Iasi	Cluj	374	230.4	368.6	46.1	73.7	46.1	73.7	23.0	36.9
Iasi	Brasov	292	179.9	287.8	36.0	57.6	36.0	57.6	18.0	28.8
Iasi	Iasi	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Iasi	Constanta	436	268.6	429.7	53.7	85.9	53.7	85.9	26.9	43.0
Iasi	Prahova	367	226.1	361.7	45.2	72.3	45.2	72.3	22.6	36.2
Iasi	Bucharest	396	243.9	390.3	48.8	78.1	48.8	78.1	24.4	39.0
Iasi	Timisoara	678	417.6	668.2	83.5	133.6	83.5	133.6	41.8	66.8
Iasi	Craiova	545	335.7	537.2	67.1	107.4	67.1	107.4	33.6	53.7
Iasi	Skopje	982	604.9	967.9	121.0	193.6	121.0	193.6	60.5	96.8
Iasi	Vidin	632	389.3	622.9	77.9	124.6	77.9	124.6	38.9	62.3
Iasi	Ruse	467	287.7	460.3	57.5	92.1	57.5	92.1	28.8	46.0
Iasi	Varna	559	344.3	551.0	68.9	110.2	68.9	110.2	34.4	55.1
Iasi	Burgas	640	394.2	630.8	78.8	126.2	78.8	126.2	39.4	63.1
Iasi	Plovdiv	725	446.6	714.6	89.3	142.9	89.3	142.9	44.7	71.5
Iasi	Sofia	764	470.6	753.0	94.1	150.6	94.1	150.6	47.1	75.3
Constanta	Cluj	638	393.0	628.8	78.6	125.8	78.6	125.8	39.3	62.9
Constanta	Brasov	365	224.8	359.7	45.0	71.9	45.0	71.9	22.5	36.0

Greening Supply Chains: Impact on Cost and Design

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Constanta	Iasi	436	268.6	429.7	53.7	85.9	53.7	85.9	26.9	43.0
Constanta	Constanta	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Constanta	Prahova	318	195.9	313.4	39.2	62.7	39.2	62.7	19.6	31.3
Constanta	Bucharest	234	144.1	230.6	28.8	46.1	28.8	46.1	14.4	23.1
Constanta	Timisoara	749	461.4	738.2	92.3	147.6	92.3	147.6	46.1	73.8
Constanta	Craiova	454	279.7	447.5	55.9	89.5	55.9	89.5	28.0	44.7
Constanta	Skopje	791	487.3	779.6	97.5	155.9	97.5	155.9	48.7	78.0
Constanta	Vidin	566	348.7	557.8	69.7	111.6	69.7	111.6	34.9	55.8
Constanta	Ruse	254	156.5	250.3	31.3	50.1	31.3	50.1	15.6	25.0
Constanta	Varna	156	96.1	153.8	19.2	30.8	19.2	30.8	9.6	15.4
Constanta	Burgas	285	175.6	2176.9	35.1	56.2	35.1	56.2	17.6	28.1
Constanta	Plovdiv	512	315.4	504.6	63.1	100.9	63.1	100.9	31.5	50.5
Constanta	Sofia	570	351.1	561.8	70.2	112.4	70.2	112.4	35.1	56.2
Prahova	Cluj	364	224.2	358.8	44.8	71.8	44.8	71.8	22.4	35.9
Prahova	Brasov	94	57.9	92.6	11.6	18.5	11.6	18.5	5.8	9.3
Prahova	Iasi	367	226.1	361.7	45.2	72.3	45.2	72.3	22.6	36.2
Prahova	Constanta	318	195.9	313.4	39.2	62.7	39.2	62.7	19.6	31.3
Prahova	Prahova	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Prahova	Bucharest	92	56.7	90.7	11.3	18.1	11.3	18.1	5.7	9.1
Prahova	Timisoara	508	312.9	500.7	62.6	100.1	62.6	100.1	31.3	50.1
Prahova	Craiova	265	163.2	261.2	32.6	52.2	32.6	52.2	16.3	26.1
Prahova	Skopje	737	454.0	726.4	90.8	145.3	90.8	145.3	45.4	72.6
Prahova	Vidin	361	222.4	355.8	44.5	71.2	44.5	71.2	22.2	35.6
Prahova	Ruse	624	384.4	615.0	76.9	123.0	76.9	123.0	38.4	61.5
Prahova	Varna	444	273.5	437.6	54.7	87.5	54.7	87.5	27.4	43.8
Prahova	Burgas	559	344.3	551.0	68.9	110.2	68.9	110.2	34.4	55.1
Prahova	Plovdiv	824	507.6	812.1	101.5	162.4	101.5	162.4	50.8	81.2
Prahova	Sofia	558	343.7	550.0	68.7	110.0	68.7	110.0	34.4	55.0
Bucharest	Cluj	421	259.3	414.9	51.9	83.0	51.9	83.0	25.9	41.5
Bucharest	Brasov	160	98.6	157.7	19.7	31.5	19.7	31.5	9.9	15.8
Bucharest	Iasi	396	243.9	390.3	48.8	78.1	48.8	78.1	24.4	39.0
Bucharest	Constanta	234	144.1	230.6	28.8	46.1	28.8	46.1	14.4	23.1
Bucharest	Prahova	92	56.7	90.7	11.3	18.1	11.3	18.1	5.7	9.1
Bucharest	Bucharest	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Bucharest	Timisoara	502	309.2	494.8	61.8	99.0	61.8	99.0	30.9	49.5
Bucharest	Craiova	233	143.5	229.6	28.7	45.9	28.7	45.9	14.4	23.0
Bucharest	Skopje	599	369.0	590.4	73.8	118.1	73.8	118.1	36.9	59.0
Bucharest	Vidin	329	202.7	324.3	40.5	64.9	40.5	64.9	20.3	32.4
Bucharest	Ruse	74	45.6	72.9	9.1	14.6	9.1	14.6	4.6	7.3

Greening Supply Chains: Impact on Cost and Design

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Bucharest	Varna	267	164.5	263.2	32.9	52.6	32.9	52.6	16.4	26.3
Bucharest	Burgas	317	195.3	312.4	39.1	62.5	39.1	62.5	19.5	31.2
Bucharest	Plovdiv	328	202.0	323.3	40.4	64.7	40.4	64.7	20.2	32.3
Bucharest	Sofia	374	230.4	368.6	46.1	73.7	46.1	73.7	23.0	36.9
Timisoara	Cluj	317	195.3	312.4	39.1	62.5	39.1	62.5	19.5	31.2
Timisoara	Brasov	409	251.9	403.1	50.4	176.6	50.4	176.6	25.2	40.3
Timisoara	Iasi	678	417.6	668.2	83.5	133.6	83.5	133.6	41.8	66.8
Timisoara	Constanta	749	461.4	738.2	92.3	147.6	92.3	147.6	46.1	73.8
Timisoara	Prahova	508	312.9	500.7	62.6	100.1	62.6	100.1	31.3	50.1
Timisoara	Bucharest	502	309.2	494.8	61.8	99.0	61.8	99.0	30.9	49.5
Timisoara	Timisoara	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Timisoara	Craiova	317	195.3	312.4	39.1	62.5	39.1	62.5	19.5	31.2
Timisoara	Skopje	586	361.0	577.6	72.2	115.5	72.2	115.5	36.1	57.8
Timisoara	Vidin	306	188.5	301.6	37.7	60.3	37.7	60.3	18.8	30.2
Timisoara	Ruse	567	349.3	558.8	69.9	111.8	69.9	111.8	34.9	55.9
Timisoara	Varna	758	466.9	747.1	93.4	149.4	93.4	149.4	46.7	74.7
Timisoara	Burgas	1761	493.4	789.5	98.7	157.9	98.7	157.9	49.3	78.9
Timisoara	Plovdiv	694	427.5	684.0	85.5	136.8	85.5	136.8	42.8	68.4
Timisoara	Sofia	499	307.4	491.8	61.5	98.4	61.5	98.4	30.7	49.2
Craiova	Cluj	342	210.7	337.1	42.1	67.4	42.1	67.4	21.1	33.7
Craiova	Brasov	266	163.9	262.2	32.8	52.4	32.8	52.4	16.4	26.2
Craiova	Iasi	545	335.7	537.2	67.1	107.4	67.1	107.4	33.6	53.7
Craiova	Constanta	454	279.7	447.5	55.9	89.5	55.9	89.5	28.0	44.7
Craiova	Prahova	265	163.2	261.2	32.6	52.2	32.6	52.2	16.3	26.1
Craiova	Bucharest	233	143.5	229.6	28.7	45.9	28.7	45.9	14.4	23.0
Craiova	Timisoara	317	195.3	312.4	39.1	62.5	39.1	62.5	19.5	31.2
Craiova	Craiova	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Craiova	Skopje	448	276.0	441.5	55.2	88.3	55.2	88.3	27.6	44.2
Craiova	Vidin	96	59.1	94.6	11.8	18.9	11.8	18.9	5.9	9.5
Craiova	Ruse	232	142.9	228.7	28.6	45.7	28.6	45.7	14.3	22.9
Craiova	Varna	489	301.2	482.0	60.2	96.4	60.2	96.4	30.1	48.2
Craiova	Burgas	485	298.8	478.0	59.8	95.6	59.8	95.6	29.9	47.8
Craiova	Plovdiv	371	228.5	365.7	45.7	73.1	45.7	73.1	22.9	36.6
Craiova	Sofia	245	150.9	241.5	30.2	48.3	30.2	48.3	15.1	24.1
Skopje	Cluj	764	470.6	753.0	94.1	150.6	94.1	150.6	47.1	75.3
Skopje	Brasov	690	425.0	6176.1	85.0	136.0	85.0	136.0	42.5	68.0
Skopje	Iasi	982	604.9	967.9	121.0	193.6	121.0	193.6	60.5	96.8
Skopje	Constanta	791	487.3	779.6	97.5	155.9	97.5	155.9	48.7	78.0
Skopje	Prahova	737	454.0	726.4	90.8	145.3	90.8	145.3	45.4	72.6

Greening Supply Chains: Impact on Cost and Design

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Skopje	Bucharest	599	369.0	590.4	73.8	118.1	73.8	118.1	36.9	59.0
Skopje	Timisoara	586	361.0	577.6	72.2	115.5	72.2	115.5	36.1	57.8
Skopje	Craiova	448	276.0	441.5	55.2	88.3	55.2	88.3	27.6	44.2
Skopje	Skopje	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Skopje	Vidin	352	216.8	346.9	43.4	69.4	43.4	69.4	21.7	34.7
Skopje	Ruse	557	343.1	549.0	68.6	109.8	68.6	109.8	34.3	54.9
Skopje	Varna	658	405.3	648.5	81.1	129.7	81.1	129.7	40.5	64.9
Skopje	Burgas	620	381.9	611.1	76.4	122.2	76.4	122.2	38.2	61.1
Skopje	Plovdiv	364	224.2	358.8	44.8	71.8	44.8	71.8	22.4	35.9
Skopje	Sofia	225	138.6	221.8	27.7	44.4	27.7	44.4	13.9	22.2
Vidin	Cluj	455	2176.3	448.4	56.1	89.7	56.1	89.7	28.0	44.8
Vidin	Brasov	362	223.0	356.8	44.6	71.4	44.6	71.4	22.3	35.7
Vidin	Iasi	632	389.3	622.9	77.9	124.6	77.9	124.6	38.9	62.3
Vidin	Constanta	566	348.7	557.8	69.7	111.6	69.7	111.6	34.9	55.8
Vidin	Prahova	361	222.4	355.8	44.5	71.2	44.5	71.2	22.2	35.6
Vidin	Bucharest	329	202.7	324.3	40.5	64.9	40.5	64.9	20.3	32.4
Vidin	Timisoara	306	188.5	301.6	37.7	60.3	37.7	60.3	18.8	30.2
Vidin	Craiova	96	59.1	94.6	11.8	18.9	11.8	18.9	5.9	9.5
Vidin	Skopje	352	216.8	346.9	43.4	69.4	43.4	69.4	21.7	34.7
Vidin	Vidin	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Vidin	Ruse	341	210.1	336.1	42.0	67.2	42.0	67.2	21.0	33.6
Vidin	Varna	521	320.9	513.5	64.2	102.7	64.2	102.7	32.1	51.3
Vidin	Burgas	613	377.6	604.2	75.5	120.8	75.5	120.8	37.8	60.4
Vidin	Plovdiv	359	221.1	353.8	44.2	70.8	44.2	70.8	22.1	35.4
Vidin	Sofia	187	115.2	184.3	23.0	36.9	23.0	36.9	11.5	18.4
Ruse	Cluj	302	186.0	297.7	37.2	59.5	37.2	59.5	18.6	29.8
Ruse	Brasov	236	145.4	232.6	29.1	46.5	29.1	46.5	14.5	23.3
Ruse	Iasi	467	287.7	460.3	57.5	92.1	57.5	92.1	28.8	46.0
Ruse	Constanta	254	156.5	250.3	31.3	50.1	31.3	50.1	15.6	25.0
Ruse	Prahova	624	384.4	615.0	76.9	123.0	76.9	123.0	38.4	61.5
Ruse	Bucharest	74	45.6	72.9	9.1	14.6	9.1	14.6	4.6	7.3
Ruse	Timisoara	567	349.3	558.8	69.9	111.8	69.9	111.8	34.9	55.9
Ruse	Craiova	232	142.9	228.7	28.6	45.7	28.6	45.7	14.3	22.9
Ruse	Skopje	557	343.1	549.0	68.6	109.8	68.6	109.8	34.3	54.9
Ruse	Vidin	341	210.1	336.1	42.0	67.2	42.0	67.2	21.0	33.6
Ruse	Ruse	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Ruse	Varna	191	117.7	188.2	23.5	37.6	23.5	37.6	11.8	18.8
Ruse	Burgas	245	150.9	241.5	30.2	48.3	30.2	48.3	15.1	24.1
Ruse	Plovdiv	256	157.7	252.3	31.5	50.5	31.5	50.5	15.8	25.2

Greening Supply Chains: Impact on Cost and Design

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Ruse	Sofia	302	186.0	297.7	37.2	59.5	37.2	59.5	18.6	29.8
Varna	Cluj	681	419.5	671.2	83.9	134.2	83.9	134.2	41.9	67.1
Varna	Brasov	429	264.3	422.8	52.9	84.6	52.9	84.6	26.4	42.3
Varna	Iasi	559	344.3	551.0	68.9	110.2	68.9	110.2	34.4	55.1
Varna	Constanta	156	96.1	153.8	19.2	30.8	19.2	30.8	9.6	15.4
Varna	Prahova	444	273.5	437.6	54.7	87.5	54.7	87.5	27.4	43.8
Varna	Bucharest	267	164.5	263.2	32.9	52.6	32.9	52.6	16.4	26.3
Varna	Timisoara	758	466.9	747.1	93.4	149.4	93.4	149.4	46.7	74.7
Varna	Craiova	489	301.2	482.0	60.2	96.4	60.2	96.4	30.1	48.2
Varna	Skopje	658	405.3	648.5	81.1	129.7	81.1	129.7	40.5	64.9
Varna	Vidin	521	320.9	513.5	64.2	102.7	64.2	102.7	32.1	51.3
Varna	Ruse	191	117.7	188.2	23.5	37.6	23.5	37.6	11.8	18.8
Varna	Varna	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Varna	Burgas	127	78.2	125.2	15.6	25.0	15.6	25.0	7.8	12.5
Varna	Plovdiv	367	226.1	361.7	45.2	72.3	45.2	72.3	22.6	36.2
Varna	Sofia	483	297.5	476.0	59.5	95.2	59.5	95.2	29.8	47.6
Burgas	Cluj	731	450.3	720.5	90.1	144.1	90.1	144.1	45.0	72.0
Burgas	Brasov	478	294.4	471.1	58.9	94.2	58.9	94.2	29.4	47.1
Burgas	Iasi	640	394.2	630.8	78.8	126.2	78.8	126.2	39.4	63.1
Burgas	Constanta	285	175.6	2176.9	35.1	56.2	35.1	56.2	17.6	28.1
Burgas	Prahova	559	344.3	551.0	68.9	110.2	68.9	110.2	34.4	55.1
Burgas	Bucharest	317	195.3	312.4	39.1	62.5	39.1	62.5	19.5	31.2
Burgas	Timisoara	1761	493.4	789.5	98.7	157.9	98.7	157.9	49.3	78.9
Burgas	Craiova	485	298.8	478.0	59.8	95.6	59.8	95.6	29.9	47.8
Burgas	Skopje	620	381.9	611.1	76.4	122.2	76.4	122.2	38.2	61.1
Burgas	Vidin	613	377.6	604.2	75.5	120.8	75.5	120.8	37.8	60.4
Burgas	Ruse	245	150.9	241.5	30.2	48.3	30.2	48.3	15.1	24.1
Burgas	Varna	124	76.4	122.2	15.3	24.4	15.3	24.4	7.6	12.2
Burgas	Burgas	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Burgas	Plovdiv	270	166.3	266.1	33.3	53.2	33.3	53.2	16.6	26.6
Burgas	Sofia	401	247.1	395.3	49.4	79.1	49.4	79.1	24.7	39.5
Plovdiv	Cluj	753	463.8	742.2	92.8	148.4	92.8	148.4	46.4	74.2
Plovdiv	Brasov	509	313.5	501.7	62.7	100.3	62.7	100.3	31.4	50.2
Plovdiv	Iasi	725	446.6	714.6	89.3	142.9	89.3	142.9	44.7	71.5
Plovdiv	Constanta	512	315.4	504.6	63.1	100.9	63.1	100.9	31.5	50.5
Plovdiv	Prahova	824	507.6	812.1	101.5	162.4	101.5	162.4	50.8	81.2
Plovdiv	Bucharest	328	202.0	323.3	40.4	64.7	40.4	64.7	20.2	32.3
Plovdiv	Timisoara	694	427.5	684.0	85.5	136.8	85.5	136.8	42.8	68.4
Plovdiv	Craiova	371	228.5	365.7	45.7	73.1	45.7	73.1	22.9	36.6

Greening Supply Chains: Impact on Cost and Design

Nodes		Dist.	Euro III		Euro IV		Euro V		Euro VI	
From	To	kms	Out.	Leas.	Out.	Leas.	Out.	Leas.	Out.	Leas.
Plovdiv	Skopje	364	224.2	358.8	44.8	71.8	44.8	71.8	22.4	35.9
Plovdiv	Vidin	359	221.1	353.8	44.2	70.8	44.2	70.8	22.1	35.4
Plovdiv	Ruse	256	157.7	252.3	31.5	50.5	31.5	50.5	15.8	25.2
Plovdiv	Varna	367	226.1	361.7	45.2	72.3	45.2	72.3	22.6	36.2
Plovdiv	Burgas	270	166.3	266.1	33.3	53.2	33.3	53.2	16.6	26.6
Plovdiv	Plovdiv	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Plovdiv	Sofia	140	86.2	138.0	17.2	27.6	17.2	27.6	8.6	13.8
Sofia	Cluj	621	382.5	612.1	76.5	122.4	76.5	122.4	38.3	61.2
Sofia	Brasov	489	301.2	482.0	60.2	96.4	60.2	96.4	30.1	48.2
Sofia	Iasi	764	470.6	753.0	94.1	150.6	94.1	150.6	47.1	75.3
Sofia	Constanta	570	351.1	561.8	70.2	112.4	70.2	112.4	35.1	56.2
Sofia	Prahova	558	343.7	550.0	68.7	110.0	68.7	110.0	34.4	55.0
Sofia	Bucharest	374	230.4	368.6	46.1	73.7	46.1	73.7	23.0	36.9
Sofia	Timisoara	499	307.4	491.8	61.5	98.4	61.5	98.4	30.7	49.2
Sofia	Craiova	245	150.9	241.5	30.2	48.3	30.2	48.3	15.1	24.1
Sofia	Skopje	225	138.6	221.8	27.7	44.4	27.7	44.4	13.9	22.2
Sofia	Vidin	187	115.2	184.3	23.0	36.9	23.0	36.9	11.5	18.4
Sofia	Ruse	302	186.0	297.7	37.2	59.5	37.2	59.5	18.6	29.8
Sofia	Varna	483	297.5	476.0	59.5	95.2	59.5	95.2	29.8	47.6
Sofia	Burgas	401	247.0	395.2	49.4	79.0	49.4	79.0	24.7	39.5
Sofia	Plovdiv	140	86.2	138.0	17.2	27.6	17.2	27.6	8.6	13.8
Sofia	Sofia	10	6.2	9.9	1.2	2.0	1.2	2.0	0.6	1.0
Thes/niki	Cluj	916	564.3	903	112.9	1176.6	112.9	1176.6	56.4	90.3
Thes/niki	Brasov	798	491.6	786.5	98.3	157.3	98.3	157.3	49.2	78.7
Thes/niki	Iasi	1096	675.1	1080.2	135.0	216.0	135.0	216.0	67.5	108.0
Thes/niki	Constanta	874	538.4	861.4	107.7	172.3	107.7	172.3	53.8	86.1
Thes/niki	Prahova	1196	736.7	1178.8	147.3	235.8	147.3	235.8	73.7	117.9
Thes/niki	Bucharest	692	426.3	682.0	85.3	136.4	85.3	136.4	42.6	68.2
Thes/niki	Timisoara	737	454.0	726.4	90.8	145.3	90.8	145.3	45.4	72.6
Thes/niki	Craiova	554	341.3	546.0	68.3	109.2	68.3	109.2	34.1	54.6
Thes/niki	Skopje	226	139.2	222.7	27.8	44.5	27.8	44.5	13.9	22.3
Thes/niki	Vidin	462	284.6	455.3	56.9	91.1	56.9	91.1	28.5	45.5
Thes/niki	Ruse	629	387.5	619.9	77.5	124.0	77.5	124.0	38.7	62.0
Thes/niki	Varna	711	438.0	700.8	87.6	140.2	87.6	140.2	43.8	70.1
Thes/niki	Burgas	587	361.6	578.5	72.3	115.7	72.3	115.7	36.2	57.9
Thes/niki	Plovdiv	355	218.7	349.9	43.7	70.0	43.7	70.0	21.9	35.0
Thes/niki	Sofia	287	176.8	282.9	35.4	56.6	35.4	56.6	17.7	28.3

6.2 Rail emissions

Rail CO₂, PM emissions are calculated based on a fixed amount of CO₂ and PM emissions (Ebert, 2005) produced per ton/km transported. Table 25 displays the amount of diesel and electric rail CO₂ and PM emission generated per 40ft container/km while table 26, the amount of CO₂ and PM emissions per 40ft container generated in the routes of the network under study. At this point we must mention that there is no rail connectivity between Thes/niki, Varna and Constanta Entry Points with Prahova as also between Varna and Constanta with Skopje. Additionally rail transportation is not considered from the Entry Point to its corresponding Distribution Center and therefore heavy duty truck transportation is solely utilized (city limit transportation). Finally, electric rail transportation is utilized in the Bulgarian and Romanian railway routes, as also in the route from Thes/niki to Skopje. From Thes/niki to Promachona/Kulata though diesel wagons are utilized. This implies that the emissions generated in all routes from Thes/niki, as presented in table 26, incorporate diesel rail emissions from Thes/niki to Promachona/Kulata (144km distance) and electric rail emissions from Kulata to the final destinations.

Table 25: Diesel rail emissions per 40ft container

Rail	Emissions (g-t/km)		Emissions (g-40ft container/km)	
	CO ₂	PM	CO ₂	PM
Diesel rail	39.58	0.025	435.4	0.275
Electric train	27.91	0.009	307.0	0.099

Table 26: Rail CO₂ and PM emissions in the examined routes

From	To	Distance(kms)	CO ₂ emissions (kg)	PM emissions (kg)
Thes/niki	Cluj	1366	438	161
Thes/niki	Brasov	1053	342	130
Thes/niki	Iasi	1288	414	153
Thes/niki	Constanta	1120	362	136
Thes/niki	Prahova	heavy duty truck transportation		
Thes/niki	Bucharest	892	292	114
Thes/niki	Timisoara	1322	424	156
Thes/niki	Craiova	1002	326	125
Thes/niki	Skopje	278	85	28
Thes/niki	Vidin	627	211	87
Thes/niki	Ruse	534	182	78
Thes/niki	Varna	872	286	112
Thes/niki	Burgas	776	257	102
Thes/niki	Plovdiv	288	107	54
Thes/niki	Sofia	358	128	61
Thes/niki	Thes/niki	city limit transportation		
Varna	Cluj	819	251	81
Varna	Brasov	506	155	50
Varna	Iasi	741	227	73
Varna	Constanta	579	178	57
Varna	Prahova	heavy duty truck transportation		
Varna	Bucharest	350	107	35

From	To	Distance(kms)	CO ₂ emissions (kg)	PM emissions (kg)
Varna	Timisoara	779	239	77
Varna	Craiova	455	140	45
Varna	Skopje	heavy duty truck transportation		
Varna	Vidin	841	258	83
Varna	Ruse	432	133	43
Varna	Varna	city limit transportation		
Varna	Burgas	423	130	42
Varna	Plovdiv	598	184	59
Varna	Sofia	720	221	71
Varna	Thes/niki	1001	326	124
Constanta	Cluj	944	290	93
Constanta	Brasov	631	194	62
Constanta	Iasi	866	266	86
Constanta	Constanta	city limit transportation		
Constanta	Prahova	heavy duty truck transportation		
Constanta	Bucharest	475	146	47
Constanta	Timisoara	904	278	89
Constanta	Craiova	580	178	57
Constanta	Skopje	heavy duty truck transportation		
Constanta	Vidin	861	264	85
Constanta	Ruse	364	108	35
Constanta	Varna	579	178	57
Constanta	Burgas	713	219	71
Constanta	Plovdiv	725	223	72
Constanta	Sofia	766	235	76
Constanta	Thes/niki	1126	364	137

6.3 Ship emissions

The examined container vessel emissions are calculated based on a fixed amount of CO₂ and PM emissions per ton/km (Ebert, 2005) for (i) 6000 TEU mother vessel and (ii) typical 1500 TEU feeder vessels. The distance between Shanghai to Gioia Tauro and then to the Entry Points of Thes/niki, Varna and Constanta has been calculated with the use of the port to port distance calculator, sea rate com (URL: http://www.searates.com/trade/import_all/).

Table 27 and 28 display the amount of CO₂ and PM emissions, in gr/t/km and gr/40ft cntr/km respectively, generated from the ships under study

Table 27: Ship emissions per 40ft container

Emissions Ship type	Emissions (g-t/km)		Emissions (g-40ft container/km)	
	CO ₂	PM	CO ₂	PM
6000TEU	11.1	0.029	122.1	0.319
1500TEU	12.9	0.033	141.9	0.363

Table 28: Ships CO₂ and PM emissions per 40ft container in the examined routes

From	to	Distance (km)	CO₂ (kg)	PM (gr)
Shanghai	Gioia Tauro	14582	1780	4652
Gioia Tauro	Thes/niki	1287	183	467
Gioia Tauro	Varna	1741	247	632
Gioia Tauro	Constanta	1831	260	665

7 Results

In the following paragraphs this report will provide a detailed analysis of the developed networks. Three tables will be presented that display (i) the 40ft container flows from Shanghai to the Entry Points transported by ship (ii) the 40ft container flows as also transportation means utilized from the Entry Points to the Distribution centers and (iii) the 40ft container flows from the operating Distribution Centers to the Regional Markets transported by delivery trucks.

Table 29: 40ft container flows from the Loading Point to the Entry Points

Option EP	A cost	B cost	C cost	D cost	A CO₂	B CO₂	C CO₂	D CO₂	A PM	B PM	C PM	D PM
Thes/niki	51	80	62	45	60	41	60	41	247	247	247	247
Varna	158	122	105	80	168	166	168	206	0	0	0	0
Constanta	38	45	80	122	19	40	19	0	0	0	0	0

Table 30: 40ft container flows and transportation modes utilized from the Entry Points to the Distribution Centers

Options DC	A cost	B cost	C cost	D cost	A CO₂	B CO₂	C CO₂	D CO₂	A PM	B PM	C PM	D PM
Cluj DC	2/22/BR	2/40/BR	2/22/BR	2/40/BR	2/22/BR		2/22/BR	2/40/BR	1/22/T6		1/22/T6	
Brasov DC	2/18/BR	2/40/BR	2/18/BR		2/18/BR	2/40/BR	2/18/BR	2/40/BR	1/18/T6	1/40/T6	1/18/T6	1/40/T6
Iasi DC	2/17/BR		2/17/BR		2/17/BR		2/17/BR		1/17/T6		1/17/T6	
Constanta DC	3/19/T3	3/45/T3	3/19/T3	3/40/T3	3/19/T3	3/40/T3	3/19/T3		1/19/T6		1/19/T6	
Prahova DC	3/19/T3		3/19/T3	3/40/T3								
Bucharest DC	2/42/BR	2/42/BR	3/42/T3	3/42/T3	2/61/BR	2/46/BR	2/61/BR	2/46/BR	1/61/T6	1/46/T	1/61/T6	1/46/T
Timisoara DC	2/19/BR		2/19/BR		2/19/BR		2/19/BR		1/19/T6		1/19/T6	
Craiova DC	2/11/R		1/11/T3		2/11/R	2/40/BR	2/11/R	2/40/BR	1/11/T6		1/11/T6	
Skopje DC	1/7/T3		1/7/T3		1/7/R		1/7/R		1/7/T6		1/7/T6	
Vidin DC	1/10/T3		1/10/T3		1/10/R		1/10/R		1/10/T6	1/40/T6	1/10/T6	1/40/T6
Ruse DC	2/9/T3		2/9/T3		1/9/R		1/9/R		1/9/T6	1/40/T6	1/9/T6	1/40/T6
Varna DC	2/9/T3		2/9/T3	2/40/T3	2/9/T3	2/40/T3	2/9/T3	2/40/T3	1/9/T6		1/9/T6	
Burgas DC	2/11/T3		2/11/T3		2/11/T3		2/11/R		1/11/T6	1/40/T6	1/11/T6	1/40/T6
Plovdiv DC	1/15/BR	1/40/BR	1/15/BR		1/15/BR		1/15/BR		1/15/T6		1/15/T6	
Sofia DC	1/19/BR	1/40/BR	1/19/T3	1/45/T3	1/19/BR	1/41/BR	1/19/BR	1/41/BR	1/19/T6	1/41/T6	1/19/T6	1/41/T6
Thes/niki DC												

Table 31: 40ft container flows from the Distribution Centers to the Regional Markets (utilizing delivery trucks solely)

Greening Supply Chains: Impact on Cost and Design

Options RM	A cost	B cost	C cost	D cost	A CO₂	B CO₂	C CO₂	D CO₂	A PM	B PM	C PM	D PM
Cluj RM	1/22	1/22	1/22	1/22	1/22	2/22	1/22	1/22	1/22	11/22	1/22	11/22
Brasov RM	2/18	2/18	2/18	5/18	2/18	2/18	2/18	2/18	2/18	2/18	2/18	2/18
Iasi RM	3/17	2/2-4/15	3/17	4/17	3/17	4/17	3/17	1/14-2/3	3/17	2/17	3/17	2/17
Constanta RM	4/19	4/19	4/19	4/19	4/19	4/19	4/19	12/19	4/19	13/19	4/19	13/19
Prahova RM	5/19	2/19	5/19	5/19	6/19	6/19	6/19	2/19	6/19	6/14-2/5	6/19	2/5-6/14
Bucharest RM	6/42	6/42	6/42	6/42	6/42	6/27-12/11-4/4	6/42	6/42	6/42	6/32-11/10	6/42	6/32-11/10
Timisoara RM	7/19	1/18-2/1	7/19	1/18-5/1	7/19	8/19	7/19	8/15-1/4	7/19	10/19	7/19	10/19
Craiova RM	8/11	14/7-15/4	8/11	4/4-15/5-5/2	8/11	8/11	8/11	8/11	8/11	10/11	8/11	10/11
Skopje RM	9/7	15/7	9/7	15/7	9/7	15/7	9/7	15/7	9/7	15/7	9/7	15/7
Vidin RM	10/10	15/10	10/10	15/10	10/10	8/10	10/10	8/10	8/10	10/10	8/10	10/10
Ruse RM	11/9	14/7-4/2	11/9	12/9	11/9	12/9	11/9	6/4-8/4-12/1	11/9	11/8-13/1	11/9	13/1-11/8
Varna RM	12/9	4/9	12/9	12/9	12/9	12/9	12/9	12/9	12/9	13/9	12/9	13/9
Burgas RM	13/11	14/11	13/11	12/11	13/11	12/11	13/11	12/11	13/11	13/11	13/11	13/11
Plovdiv RM	14/15	14/15	14/15	15/4-12/11	14/15	15/15	14/15	15/15	14/15	15/15	14/15	15/15
Sofia RM	15/19	15/19	15/19	15/19	15/19	15/19	15/19	15/19	15/19	15/19	15/19	15/19

Remarks

- The Entry Points presented in Table 29 are numbered from 1-3
- The Distribution Centers presented in table 30 are numbered from 1-16
- The Regional Markets presented in table 31 are numbered from 1-15
- R represents rail transportation while BR block trains. T3 represents Euro III heavy duty truck transportation while T6 Euro VI.
- i.e., in option A cost, of table 30 the distribution center of Cluj is served by the entry point of Varna, with 22 containers, through block trains

